SFitter: Combining LHC Data with Flavor Stuff

Tilman Plehn

University of Edinburgh

Pheno family reunion, 4/2008

Outline

Phenomenology in the LHC era

Underlying parameters

Flavored SFitter

SFitter status

Phenomenology in the LHC era

All hopes on the LHC

- find light Higgs?
- find new physics stabilizing Higgs mass?
- see dark–matter candidate?
- early data: playing a fun game
  understood data: test TeV-scale models

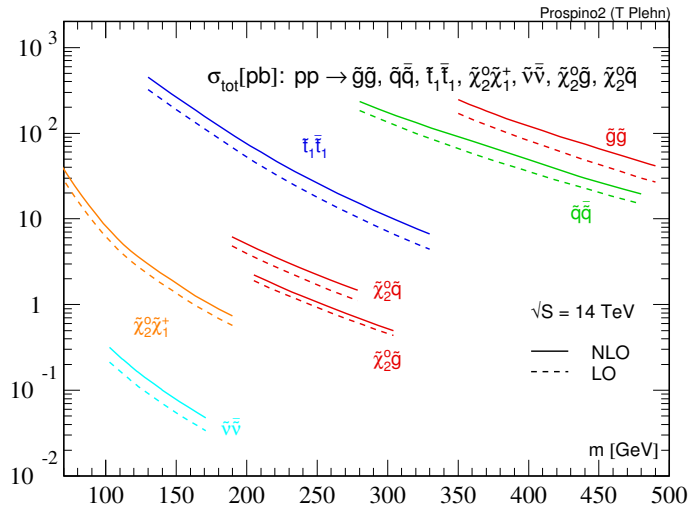
Particle theory in the LHC era

- test huge number of hypotheses [given too much time for model builders]
- forget about model–independent analyses [tough LHC environment]
- link to other observations [DM+Tevatron propaganda uncovered: Hooper, TP, Vallinotto]
- reconstuct TeV-scale Lagrangian

Role of LHC

- beyond inclusive searches [that was Tevatron]
  millions of new strongly interacting particles

$\Rightarrow$ (1) try to survive QCD
(2) aim at underlying theory



Underlying parameters

From kinematics to weak–scale parameters [Fittino; SFitter: Lafaye, TP, Rauch, Zerwas]

- parameters: weak-scale Lagrangian
- measurements: kinematic endpoints, branching ratios, rates [Prospino2]
  B decays, $(g-2)_\mu$, dark matter, e-w precision data...
- errors: general correlation, statistics & systematics & theory [flat theory errors!]
- problem in grid/fit: no local/global maximum
  problem in physics: secondary maxima

Underlying parameters

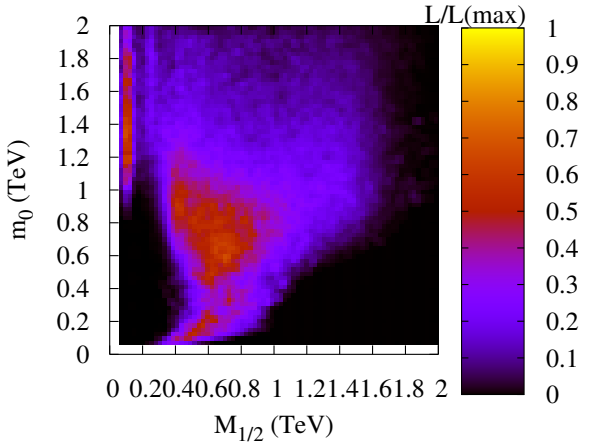
From kinematics to weak–scale parameters [Fittino; SFitter: Lafaye, TP, Rauch, Zerwas]

- parameters: weak-scale Lagrangian
- measurements: kinematic endpoints, branching ratios, rates [Prospino2]
  B decays, $(g-2)_\mu$, dark matter, e-w precision data...
- errors: general correlation, statistics & systematics & theory [flat theory errors!]
- problem in grid/fit: no local/global maximum
  problem in physics: secondary maxima

Probability maps of new physics [Baltz,...; Roszkowski,...; Allanach,...; SFitter]

- undisputed: exclusive likelihood map $p(d|m)$ over m [hard part]
- general problem: remove directions
- Bayesian: $p(m|d) \sim p(d|m)\ p(m)$ with theory bias $p(m)$
  'How does dark matter annihilate/couple?'
- frequentist: best–fitting point $\max_m p(d|m)$
  'Which is the most likely parameter point?'

  [Allanach, Cranmer, Lester, Weber]



Underlying parameters

From kinematics to weak–scale parameters [Fittino; SFitter: Lafaye, TP, Rauch, Zerwas]

- parameters: weak-scale Lagrangian
- measurements: kinematic endpoints, branching ratios, rates [Prospino2]
  B decays, $(g-2)_\mu$, dark matter, e-w precision data...
- errors: general correlation, statistics & systematics & theory [flat theory errors!]
- problem in grid/fit: no local/global maximum
  problem in physics: secondary maxima

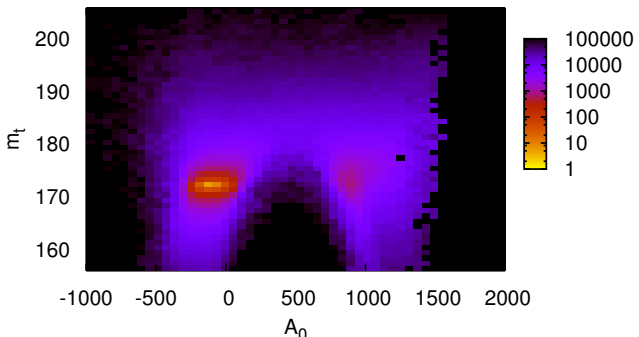
Toy model: MSUGRA map from LHC [LHC endpoints with free y_t]

- weighted Markov chains [similar to: Ferrenberg & Swendsen]

$$P_{\text{bin}}(p \neq 0) = \frac{N}{\sum_{i=1}^{N} 1/p}$$

- SFitter output #1: fully exclusive likelihood map
  SFitter output #2: ranked list of local maxima

$\Rightarrow$ correlations and seconday maxima mean need for more measurements

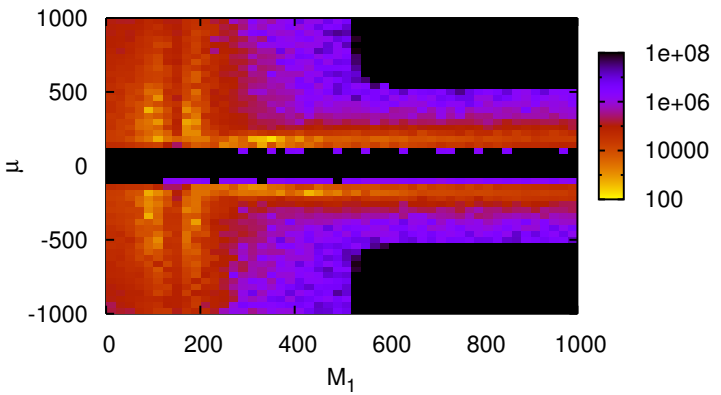


χ^2	m_0	$m_{1/2}$	$\tan\beta$	A_0	μ	m_t
0.3e-04	100.0	250.0	10.0	-99.9	+	171.4
27.42	99.7	251.6	11.7	848.9	+	181.6
54.12	107.2	243.4	13.3	-97.4	-	171.1
70.99	108.5	246.9	13.9	26.4	-	173.6
88.53	107.7	245.9	12.9	802.7	-	182.7
...						

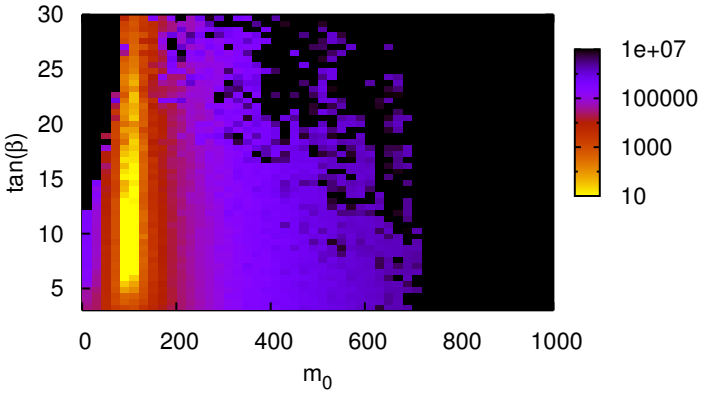
Underlying parameters

MSSM map in LHC era [SFitter+friends]

- from 6 to 19 parameter dimensions [killing grids, Minuit, laptop–style fits...]
- SFitter outputs still the same, best points degenerate
- LHC edges: sign(μ) unknown [Allanach...]



- LHC edges: tan β from m_h believe–based and poor [even in mSUGRA]



- LHC rates: tan β from heavy Higgs tough [Kinnunen, Lehti, Moortgat, Nikitenko, Spira]
- flavor physics finally of BSM use? [Polesello in Cern flavor-LHC report]

Flavored SFitter

Flavor physics in the LHC era

- traditional flavor observables: $\text{BR}(B_s \to \mu\mu) \sim \tan^6 \beta$ [SFitter + Jäger, Spannowsky]
  $(g-2)_\mu \sim \tan \beta$ [SFitter + Alexander, Kreiss]
- serious physics: errors the key

Flavored SFitter

Flavor physics in the LHC era

- traditional flavor observables: $\text{BR}(B_s \to \mu\mu) \sim \tan^6 \beta$ [SFitter + Jäger, Spannowsky]
  $(g-2)_\mu \sim \tan\beta$ [SFitter + Alexander, Kreiss]
- serious physics: errors the key
- BR($B_s \to \mu\mu$) combined with stop–chargino sector [Hisano, Kawagoe, Nojiri]
- 7% error on f_{B_s} by 2015 crucial perturbative effects secondary [Della Morte, Del Debbio]

	no theory error			$\Delta\text{BR}/\text{BR} = 15\%$	
	true	best	error	best	error
tan β	**30**	**29.5**	**3.4**	**29.5**	**6.5**
M_A	344.3	344.4	33.8	344.3	31.2
M_1	101.7	100.9	16.3	100.9	16.4
M_2	192.0	200.3	18.9	200.3	18.8
M_3	586.4	575.8	28.8	575.8	28.7
μ	345.8	325.6	20.6	325.6	20.6
$M_{\tilde{t},R}$	430.0	400.4	79.5	399.8	79.5

Flavored SFitter

Flavor physics in the LHC era

- traditional flavor observables: $\text{BR}(B_s \to \mu\mu) \sim \tan^6\beta$ [SFitter + Jäger, Spannowsky]
  $(g-2)_\mu \sim \tan\beta$ [SFitter + Alexander, Kreiss]
- serious physics: errors the key
- $\text{BR}(B_s \to \mu\mu)$ combined with stop–chargino sector [Hisano, Kawagoe, Nojiri]
- 7% error on f_{B_s} by 2015 crucial [Della Morte, Del Debbio]
  perturbative effects secondary

	no theory error			$\Delta\text{BR}/\text{BR} = 15\%$	
	true	best	error	best	error
$\tan\beta$	**30**	**29.5**	**3.4**	**29.5**	**6.5**
M_A	344.3	344.4	33.8	344.3	31.2
M_1	101.7	100.9	16.3	100.9	16.4
M_2	192.0	200.3	18.9	200.3	18.8
M_3	586.4	575.8	28.8	575.8	28.7
μ	345.8	325.6	20.6	325.6	20.6
$M_{\tilde{t},R}$	430.0	400.4	79.5	399.8	79.5

- $(g-2)_\mu$ combined with slepton–neutralino sector [review: Stöckinger]
- already current precision promising

	LHC	LHC $\otimes(g-2)$	SPS1a
$\tan\beta$	**10.0± 4.5**	**10.3± 2.0**	**10.0**
M_1	102.1± 7.8	102.7± 5.9	103.1
M_2	193.3± 7.8	193.2± 5.8	192.9
M_3	577.2±14.5	578.2± 12.1	577.9
μ	350.5±14.5	352.5± 10.8	353.7
$M_{\tilde{\mu},R}$	135.0± 8.3	135.6± 6.3	135.8
$M_{\tilde{q},R}$	507.3±17.5	507.6± 15.8	508.1

- technical fitting/scanning issues solved and implemented in SFitter
- work to be done, community focus not helpful?

SFitter status

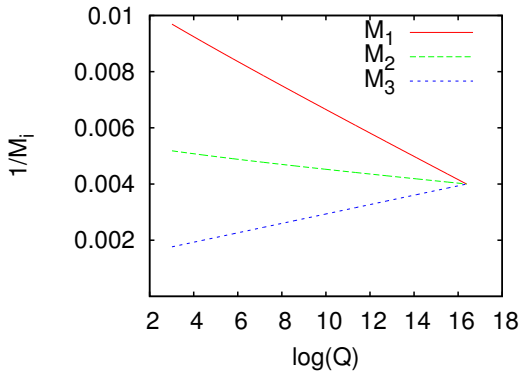
Physics in the LHC era

- understand e-w symmetry breaking
- confirm new physics [dark matter]
- complete Standard Model

Fundamental theory

- SUSY breaking?
- unification, GUT?
- scale-invariant sum rules? [Cohen, Schmalz]
- renormalization group bottom–up [SFitter + Kneur]

$\Rightarrow$ LHC sensitive to UV models



Technical status

- 20D parameter spaces under control [including statistics and errors]
- give us time to apply methods
- collaborations and suggestions welcome

SFitter: Combining LHC Data with Flavor Stuff

Tilman Plehn